Hunter-gatherers Living in a Flooded World: The Change of Climate, Landscapes and Settlement Patterns during the Late Palaeolithic and Mesolithic on Bornholm, Denmark

Lasse Sørensen and Claudio Casati

Abstract

The change towards a warmer climate and flooded landscapes during the Early Holocene is investigated on the basis of a regional study on Bornholm. The environmental consequences are discussed together with the impact all these changes had on the hunter-gatherers ability to colonise new regions, when living in a flooded world. Bornholm was, despite being a peninsula, a marginal region during the Late Palaeolithic although visits of pioneering hunter-gatherers became more frequent during the Preboreal. Improved environmental conditions during the following Boreal stage were characterized by an expansion and consolidation of animals and humans in the region. During the following Middle and Late Boreal, the land bridge was flooded and Bornholm became an island. The flooded landscape changed the way hunter-gatherers interacted and communicated, thus creating new social systems, where Bornholm again became a marginal zone. The island was not recolonised before the Late Ertebølle (4500–4000 cal. BC). The hunter-gatherers most important faculties, when living in this flooded world, were the ability to adapt to the changing landscape and maintaining cultural as well as social contacts with other synchronic societies in the Baltic region. When social interaction became too difficult, some hard priorities had to be made and some regions were abandoned.

Introduction

During the Late Palaeolithic and Mesolithic the northern European Plain was characterized by a gradual flooding of huge landmasses, which was caused by a warmer climate change and the melting of the Northern American ice core. Few archaeological studies have discussed what consequences these changes of climate and landscape would have for these hunter-gatherers, which lived in a flooded world. We will discuss if the change of climate and landscapes had an effect on the settlement patterns on Bornholm, Denmark, during the Maglemose Culture (9400–6500 cal BC). Bornholm was alternately connected to modern Germany-Poland or an island during certain stages of the Late Palaeolithic (12500–9400 cal BC) and Early Mesolithic (9400–6000 cal BC), making it an interesting area for studying processes of colonisation. In particular, the impact of the changing sea level and changing environmental situation makes it especially fascinating to investigate how these hunter-gatherers adapted to the changed conditions in the landscape. Finally, there are some interesting local perspectives which emerge in studying the site densities from the Late Palaeolithic and Early Mesolithic, as they can reveal issues of mobility and shed light on when Bornholm was colonised, or possibly isolated.

Exotic raw materials reveal the pioneering habitation

The raw materials in the southern Baltic are all procured from secondary deposits, brought to the region by glaciers in the quaternary period (Becker 1990). The local hunter-gatherers had detailed knowledge of where to find the different raw materials in the Mesolithic landscape. Contact between the Baltic regions and Bornholm can be identified, because Senonian flint does not occur naturally on Bornholm (Casati and Sørensen 2006: 10f). Our investigations have shown that Late Palaeolithic and Mesolithic hunter-gatherers did have some contact with the flint producing areas in the western Baltic area, based on the imported Senonian artefacts found on several sites (see below). It is difficult to understand how this exchange worked. It is hardly a question of trade, but rather a result of a mobility pattern with sporadic contact with the western Baltic area. The possibilities of maintaining contact with other hunter-gatherers were also dependent on the geographical development in the Baltic region.

The paleogeography of Bornholm and the southern Baltic

The changes in land and sea that take place in the development of the Baltic Sea during the Late Glacial and Early Holocene had a great influence on the environmental conditions for both the humans and animals which inhabited Bornholm and the southern Baltic region (fig. 1). The Late- and Postglacial landscape on the Northern European Plain is influenced by some major changes in sea levels (*eustacy*) and uplift of land (*isotacy*). At the end of the last Ice Age, large quantities of water were stored in the icecaps of both North and South Poles and in Scandinavia. This resulted in a sea level much lower than at the present, where the North Sea was an area of settlement during the Late Palaeolithic and Early Mesolithic (Coles 1998: 45ff).

The development of the Baltic Basin during the Late- and Postglacial is complex due to differences in the glacio-isostatic uplift, which had a major impact on the geographical development of Bornholm, and the land bridges that connected Bornholm with Germany and Poland (Björck 1995: 19ff; Jensen et al. 1999: 437ff, 2002: 5ff). This is one of the main reasons why the paleogeography plays such an important role in understanding when humans and different types of animals migrated to Bornholm during the Late Palaeolithic and Early Mesolithic.

During the Baltic Ice Lake stage, 12500–9500 cal BC, the Yoldia Sea stage, 9500–8500 cal BC, and the Ancylus Lake stage, 8500–7000 cal BC, Bornholm was either the northern part of a peninsula, or an island with a substantial land bridge towards Vorpommeren (fig. 2). This land bridge created a bay on either side of Bornholm. The western side was orientated towards the Arkona Basin, and the eastern side was located where the Oder River had its outflow. The land bridge consists of two different ridges called Rønne Bank and Adler Ground, which stretch in a southwestern direction with a width of 15–17 km (fig. 3A and 3B). Today the shoals lie 12–20 m underwater, as confirmed by the detailed bathymetric investigations made by Nielsen et al. (2004: 87ff) and Uścinowicz (2006). Furthermore, the shoals are separated by a northwest to southeast depression a few kilometres wide, with water depths of 20–25 m. The chart also shows that between Adler Ground and the Bay of Pomerania, there is a stretch of 10 km where the shoals drop away and the depth is as much as 30 m (Bennike and Jensen 1998: 30f; Jensen et al. 1999: 439f).

Drowned tree stumps of pine (*Pinus Sylvestris*) have been fished out pre-

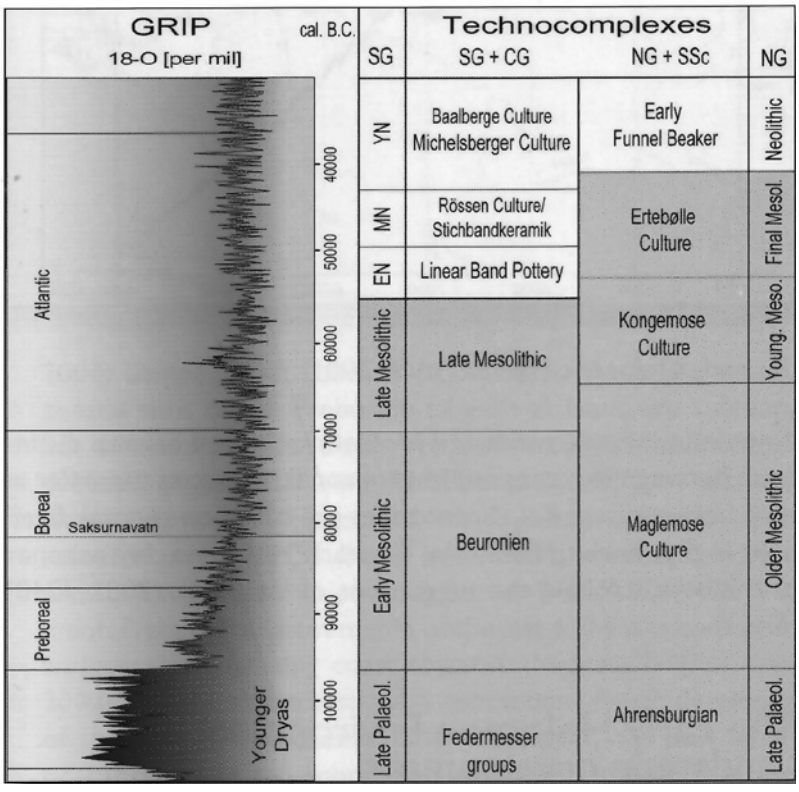


FIGURE 1: *Chronostratigraphy of the Mesolithic. SG – Southern Germany. CG – Central Europe. NG – Northern Germany. SSc – Southern Scandinavia. (After Terberger 2006: 113)*

viously by fishermen on Rønne Bank and Adler Ground, indicating that these shoals were once part of a land bridge (fig. 3; Nielsen 1986a). However, none of these tree stumps have been ^{14}C dated, and until the beginning of the BALKAT project[1], a lack of data limited any understanding of the shore level curves in this part of the Baltic Sea (Jensen et al. 2002: 2ff). The land bridges were permanently flooded during the Littorina Sea transgressions (7000–3000 cal BC). Between 7000–6000 cal BC, the transgressions flooded the land bridge gradually, creating several smaller islands including Rønne Bank, Adler Ground, Bank of Oder and Słupsk Shoal (fig. 3C). It is currently not clear when these smaller shoals were flooded, but sometime

1 The purpose of the BALKAT project is to investigate the geographical development since the last ice age in the southwestern parts of the Baltic Sea. The results give new insights within climate history, environmental history and cultural history of the Baltic Sea.

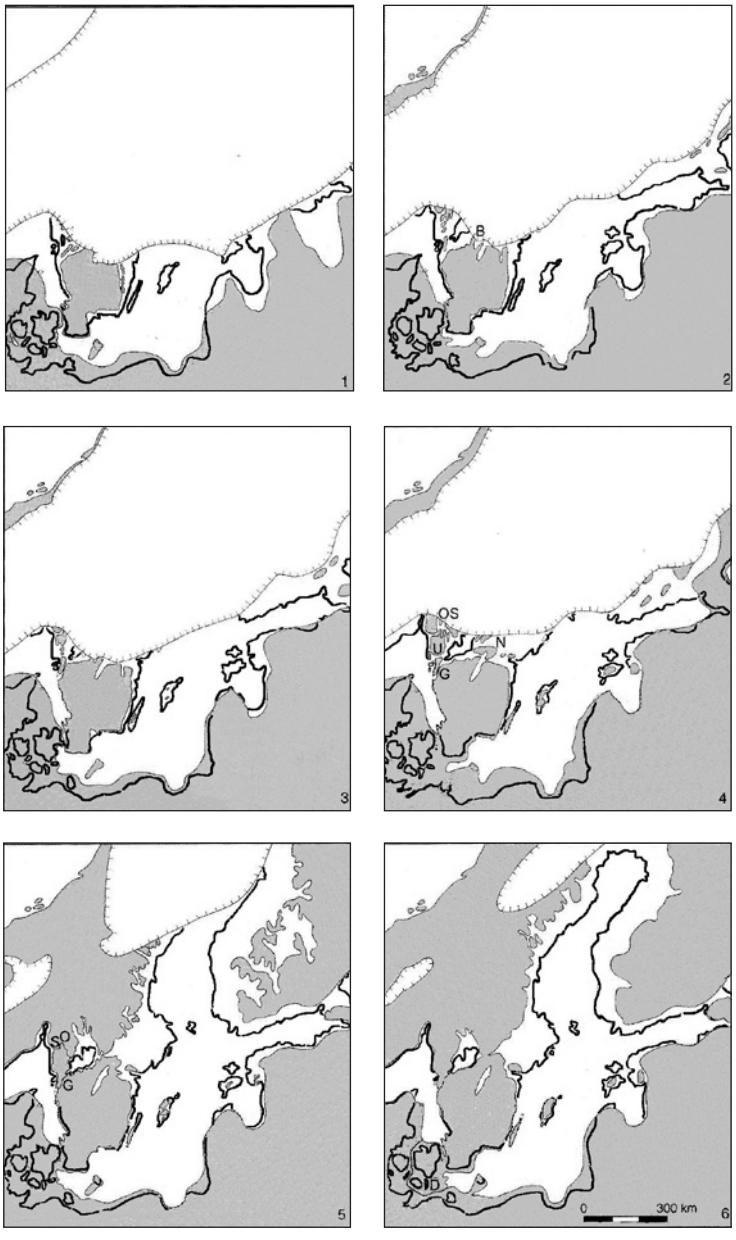
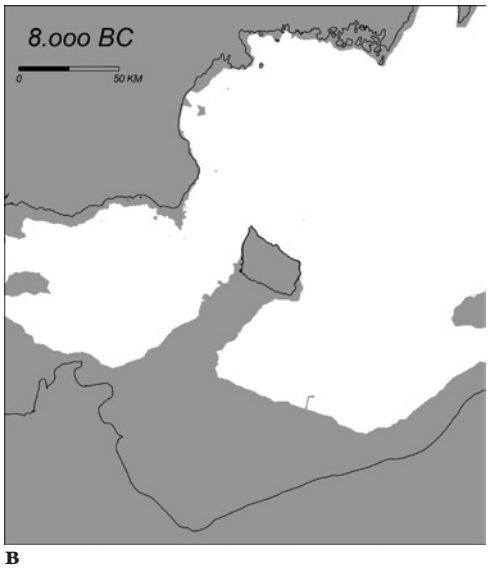


FIGURE 2: *The development of the Baltic Sea. 1: The first stage of the Baltic Ice Lake (12500 cal BC). 2: The second stage of the Baltic Ice Lake before the breakthrough at Mount Billingen (11000 cal BC). 3: The drainage at Mt. Billingen in the south-central part of Sweden lowered the sea level to about 25 m. below the current sea level (10300 cal BC). 4: The Yoldia Sea with the open strait in the south-central part of Sweden (9500–9300 cal BC). 5: The closing of the strait in the south-central part of Sweden created the Ancylus Lake with drainage through the Göta Älv and the Otteid-Stenselva system. The drainage lowered the water level to 10–15 m. below the current sea level (8600–8400 cal BC). A regression followed around 8200–8000 cal BC, which recreated the land bridge towards Bornholm with water levels of approximately 25–35 m. below the current sea level. The proposed drainage through the Dana River is questioned. (After Björck 1995: 19ff; Lemke 2004: 46; Jensen et al. 2002)*

A



B

C

FIGURE 3: *Paleogeographic map of the southern part of the Baltic Sea.*

A: Around 11000 cal BC, at the time of the Baltic Ice Sea.

B: Around 8000 cal BC, when Bornholm was the northern part of a peninsula, due to the constant low water level in the Ancylus Lake and the strong regression in the area.

C: Around 5100 cal BC. Bornholm is an island and towards the south, some smaller islands on the Adlers Ground and the Banks of Rønne and Oder are visible. (After Casati and Sørensen 2006: 13)

after 6000 cal BC seems probable. The land bridge was more or less permanent from 12000 to 7000 cal BC, inviting animals and humans to migrate into this part of the Baltic region.

Flora and fauna on Bornholm during the Late Glacial

The environmental conditions on Bornholm are of cardinal importance in order to understand what awaited the first humans, who potentially could walk across the land bridge during the Late Glacial and Early Mesolithic. The pollen diagram from the Vallensgård peat bog (Iversen 1954: 87ff; Usinger 1977: 5ff) offers vital information on the Late Glacial and Preboreal vegetation history on Bornholm. The flora that spread across the land bridge after Bornholm became ice free during Bølling (zone Ib) and Older Dryas (Dryas II) (zone Ia) was a treeless tundra vegetation. The flora of this tundra consisted of the hardy white dryas (*Dryas octopetala*), which could resist long periods of hard winter.

Currently, there are no data to indicate any migration of either animals or humans during Bølling (12500–12000 cal BC) and Older Dryas (12000–11800 cal BC). Reindeer (*Rangifir tarandus*) is the only larger mammal registered on Bornholm, as proven by three early ^{14}C dates to the following Allerød period (11800–11000 cal BC) from Pellegård, Dyndeby and Klemensker (Aaris-Sørensen et al. 2007: 917ff) (fig. 4). According to Aaris-Sørensen (1998: 21), it is probable that also elk (*Alces alces*) and beaver (*Castor fiber*) were present on Bornholm during the Allerød.

According to Usinger (1977), the Allerød layer in Vallensgård Mose during the following period shows a threefold division, with a cooler phase in the middle. Both before and after this phase, higher values of junipers (*Juniperus*) seem to indicate two climatic optima. These interpretations correspond to the pollen diagram made by Iversen (1954), which concludes that Bornholm had a warmer climate than Jutland during the Allerød (11800–11000 cal BC), thus explaining the presence of reindeers.

The main support for stating a warmer Allerød climate on Bornholm is the higher number of pollen from pine and birch (*Betula*) in the Vallensgård Mose, compared with other pollen diagrams from Jutland. The approximately 40% of pine and birch indicate that a light open forest was present on Bornholm during Allerød (Usinger 1977). However, many of these bogs may reveal more about the local history of flora than about general trends,

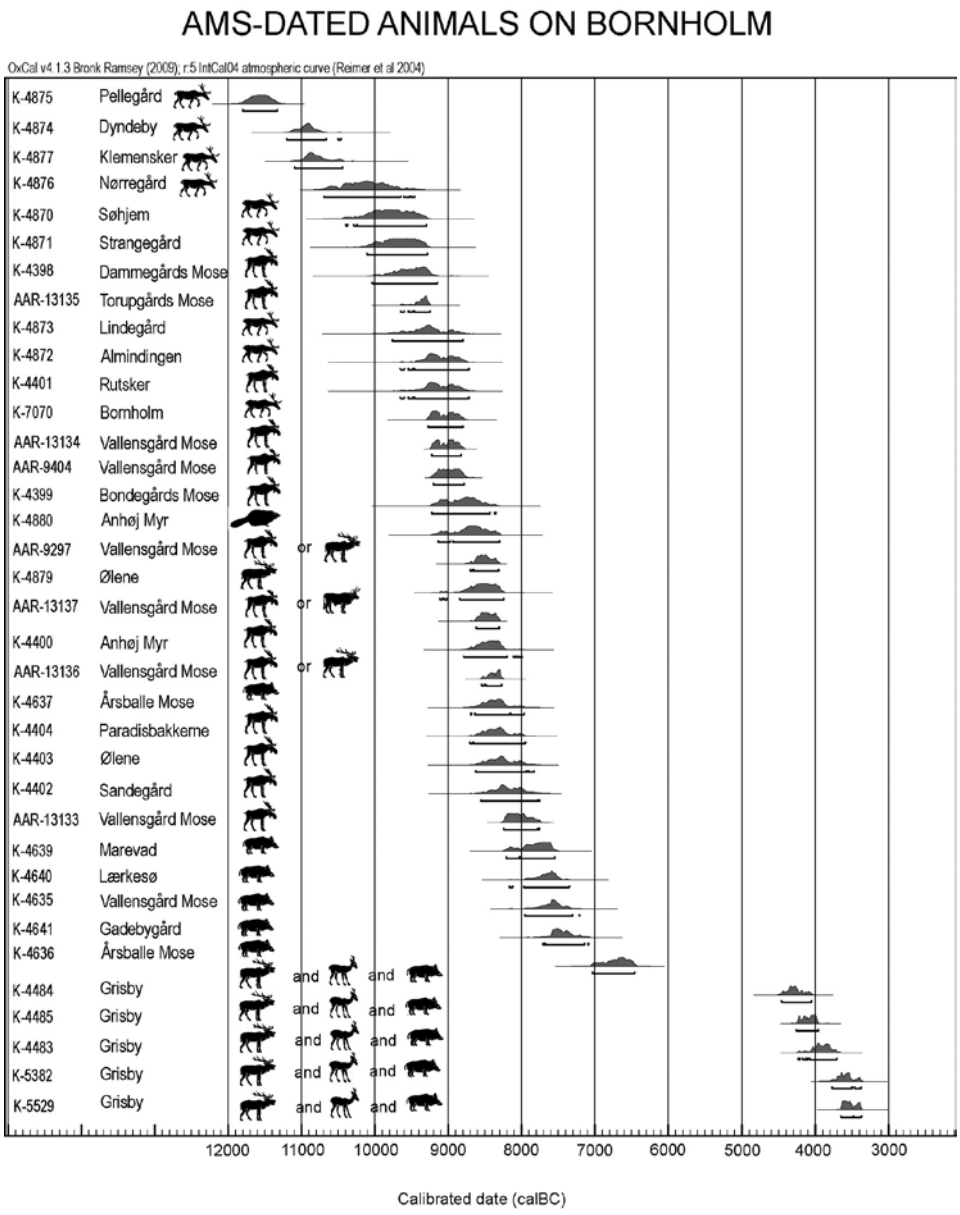


FIGURE 4. *^{14}C dates of animals on Bornholm, showing the faunal development during the Late Palaeolithic and Mesolithic. (Data compiled from Aaris-Sørensen 1998; Vang Petersen 2001: 161ff; Aaris-Sørensen et al. 2007: 914ff).*

and Vallensgård Mose is no exception, because the bog is more or less sheltered by protruding bedrock to the north (fig. 6A). As such, the bog may have provided a "sanctuary" for some forms of vegetation in both harsher and milder climates, and this could in turn mean that the pollen diagram does not reflect more general conditions (Casati et al. 2004: 113ff). Thus, it must be concluded that Bornholm conforms to the general picture of the Allerød climate and flora in southern Denmark. Within the Allerød layer in Vallensgård Mose, Usinger found some microtephra associated with the volcanism of the Laacher See in the Eifel Mountains, dated to 10932 cal BC, thus placing the layer containing the tephra immediately after the cooler middle part of the Allerød period, which corresponds with the Late Allerød layer in the pollen diagram (Usinger 1977; Street 1986; Baales et al. 1999, 2002; Schmincke et al. 1999; Riede 2008: 591ff; Sørensen 2010: 276ff).

When was Bornholm settled for the first time?

The lithic assemblage from the Vallensgård site, which can be associated with the Bromme Culture, suggests that Bornholm was settled for the first time sometime during the Allerød period. The Vallensgård site is located on a small sandy hilltop on the edge of a bog at the centre of the island near Rytterknægten (fig. 6A). Stray finds from three neighbouring Palaeolithic sites have been registered, as well as some Neolithic settlements overlying these sites (Casati and Sørensen 2006: 14ff). The Vallensgård site was excavated in 1986 and has only been published briefly (Nielsen 1986b: 77). The assemblage consists of worked flint found in a layer that was cryoturbated during either the permafrost in Dryas III (10650–9500 cal BC) or during the Preboreal Oscillation (9300–9150 cal BC). Nielsen (1986b: 77) argues for a typological dating of the lithic material to the Bromme Culture.

The lithic material consists of flakes, blades, cores, two end scrapers and one tanged point. The main part of the assemblage originates from the surface, including the tanged point which was lying stratigraphically above the cryoturbated layer. Recent surveys of the Vallensgård sites have confirmed that it is still possible to find Palaeolithic artefacts on the surface. The bluish patina, shape and technology are especially characteristic of the Palaeolithic artefacts, making them different from the Neolithic material. The Late Palaeolithic material consists of Senonian flint of the highest quality. Some flakes from the cryoturbated layer had a thick chalky cortex, indicating that

the raw material at Vallensgård Mose was imported and probably procured in the western part of the Baltic region, although it cannot be excluded that it was possible to find Senonian flint within the Late Glacial landscape on the land bridge towards Bornholm.

The hunter-gatherers at the Vallensgård site had limited knowledge of exploiting the local raw nodules. Furthermore, the lithic technology is characterised by an expedient production, thus indicating that we are dealing with pioneering hunter-gatherers settling this region during the Allerød. Many of the Late Palaeolithic sites have been associated with possible reindeer routes. However, recent analysis of seasonal markers proves that southern Scandinavia acted as a calving area throughout the Late Glacial and Early Holocene, thus refuting the north-southern route and supporting the east-western route. The reality of these pioneering hunter-gatherers is therefore much more complex than previously thought, and encouraged them to supplement reindeer and elk hunting with marine resources from the shores of the Baltic Ice Lake and Yoldia Sea. Bornholm was a marginal area during the Late Glacial, proving that environmental advantages did not always attract hunter-gatherers during the Late Palaeolithic.

Flora and fauna during the Late Glacial and Early Holocene

The following Younger Dryas (Dryas III) was a colder period, as shown in the Vallensgård pollen diagram. The vegetation consisted mainly of birch (*Betula*) and willow (*Salix sp.*) (20–30 %), pine (*Pinus*) (20–30%) and wind resistant, herbaceous plants and heather (approx. 50%; Usinger 1977). These percentages are roughly comparable with the rest of southern Denmark, although Bornholm seems to have a slightly higher percentage of pine pollen and thus a larger amount of pine trees. However, once again the sheltered surroundings of Vallensgård Mose could explain these differences. The colder climate, and the fact that Bornholm was an island at high sea levels and had a substantial land bridge with shallow seas, did not stop the reindeer from migrating to the area during Dryas III. 70 of the 280 finds of reindeer from Danish prehistory have been made on Bornholm, and nine have been ^{14}C dated (fig. 4). Three of these date back to the Dryas III, where the results from Nørregård, Søhjem and Strangegård belong to the middle and later part of the Dryas III. The dates prove that reindeer were present

throughout the Dryas III. A study by Aaris-Sørensen et al. (2007: 917) also proves that reindeer moved around in the vicinity of the Baltic Ice Lake, as shown by ^{14}C dates from Køge Bugt. Additionally, an elk bone from Veddelev Havn dated to 10540 ± 110 BP, K-3493 (10703–10150 cal BC) indicates the possibility of elk living near the Baltic Ice Lake (Aaris-Sørensen 1998: 105). Furthermore, the recently published site of Hässleberga, a group of kettle holes in southwestern Scania, has also yielded ^{14}C dates of reindeer from the Dryas III chronozone (Larsson et al. 2002: 61ff). Currently, the reindeer remains found on Bornholm display no certain signs of human activity such as cut marks and marrow fracturing. Nevertheless, reindeer were present on Bornholm during Dryas III; only the question of their numbers remains to be answered.

Lack of settlements from the Ahrensburgian culture during the Dryas III

The lack of settlements from the Ahrensburg Culture is remarkable because the island was connected to the mainland, giving a safe passage for reindeer during the entire period of Dryas III. A climatic explanation involving colder climate during Dryas III has been suggested for the lack of Ahrensburg material on Bornholm. However, the same climate is observed in the areas surrounding Bornholm, where Ahrensburgian sites occur. The identification of Ahrensburgian sites becomes even more complicated if these settlements consist of lithic assemblages from the Early Mesolithic, as illustrated by the Epi-Ahrensburgian inventories, which is defined by the presence of microliths and the absence of tanged points (Brinch Petersen 2009: 110ff). Future studies are needed to confirm the existence of the transitional Epi-Ahrensburgian group. However, the fact remains that while purposeful reconnaissance is responsible for a number of Maglemose settlements, no Ahrensburgian sites have so far been discovered on Bornholm.

Flora and fauna during the Preboreal

The warmer climate during the Preboreal (9700–8300 cal BC) changed the vegetation to a more dense pine and birch forest, as confirmed by different pollen diagrams in southern Scandinavia and by the deposited snow from

the Greenland ice cores which show a fast rise in temperature (Iversen 1954; Noe-Nygaard et al. 2006: 303ff). The faunal picture from the beginning of the Preboreal – containing reindeer, elk and beaver – proves that Bornholm had a wide range of animals during this period (fig. 4). The Preboreal Oscillation (9300–9150 cal BC), a colder phase lasting approximately 100 to 150 years, could be one of the reasons why reindeer have been found on Bornholm and southern Scandinavia during the Early Preboreal (Aaris-Sørensen 2007: 918).

Elk were also present in the Preboreal and are known from forty bog finds on Bornholm. Seven of these have been ^{14}C dated, indicating a regular and stable population of elk (fig. 4). Another important animal from the Preboreal, the beaver, has been found on Anhøj Myr and dated to 9380 ± 130 BP, K-4880 (9137–8304 cal BC). Finally, towards the end of the Preboreal, the fauna becomes even more diversified, with the earliest evidence of fox (*Vulpes vulpes*), pine marten (*Martes martes*), polecat (*Mustela putorius*), roe deer (*Capreolus capreolus*), red deer (*Cervus elaphus*) and wild boar (*Sus scrofa*). It is, though, only the red deer from Ølene (9270 ± 130 BP, K-4879, 9114–8244 cal BC) and the wild boar from Årsballe Mose (9120 ± 120 BP, K-4637, 8695–7966 cal BC) which confirm the presence of these animals during the later stages of the Preboreal (Aaris-Sørensen 1998: 128). Another important event during the Preboreal was the open passage to the North Sea through the Yoldia Sea (9500–8500 cal BC), which attracted a wide range of marine animals (fig. 2). Around 8500 cal BC, the glasio-isostatic uplift closed the south central Swedish connection from the Baltic Basin. This development had a major impact on the ring seal (*Phoca hispida*), which became a relict population (Aaris-Sørensen 1998: 94; Fredén 1988). The same thing happened to the Baltic salmon (Karlsson and Karlström 1994: 62f). The detailed knowledge of the flora and fauna suggests some environmental advantages, which could be exploited by migrating hunter-gatherers. The sparse finds from these pioneers are presented below.

The early Maglemose on Bornholm during the Preboreal

The Lundebro material is the only lithic assemblage from the Early Preboreal and consists of four blades, four lanceolates and some microburins (fig. 6A). These are made of Senonian flint, and are three times larger than artefacts made from local raw materials (Nielsen 2001: 91ff). The local raw material

is dominated by the so-called Kugleflint, a Maastrichtian flint type commonly found as small round nodules of approximately 5-8 cm in diameter. The artefacts produced from these nodules are, by default, small. The thick chalky cortex observed on one of the blades of senonian flint from Lundebro indicates that we are dealing with a unique assemblage which includes imported raw materials. The raw nodules used in this assemblage were probably procured from a primary source in the western Baltic area or on the land bridge towards Bornholm. The site was located near the coast where 58 m^2 were excavated in 1994–95. The site could benefit from further excavation in order to document the stratigraphy, collect a larger lithic assemblage and materials for ^{14}C dates. The small assemblage of senonian flint was found in the lower layers of the site, whereas the upper layers were dominated by lanceolates and triangles made from local raw materials (Nielsen 2001: 93ff).

Organic finds from the Early Maglemose culture during the Preboreal

A few stray organic finds from Bornholm can also be associated with the Early Maglemose Culture. These finds consisted of harpoons, leisters and a perforated tooth from a wild boar. Their exact position within the bog is unknown, but they were all found at the bottom of the calcareous marl, indicating that these objects were used by some of the earliest hunter-gatherers during the Dryas III and Preboreal. However, all artefacts were ^{14}C dated to the Preboreal, except for one bone point that was dated to the Early Boreal (fig. 5; Becker 1952: 167ff). The large-barbed harpoons have previously been interpreted as fishing implements (Andersen 1976: 17; Heidelk-Schacht 1984: 11). But no "fish corrosion" has been observed on any of the harpoons at hand (Sarauw 1903: 258). An alternative interpretation of the harpoons from Vallensgård Mose and other inland lakes on the Northern European Plain proposed by Vang Petersen (2009) is that they indicate a hunting method where the elk or reindeer were driven into the water, possibly with the help of dogs, and then harpooned from a canoe. The method is also known from ethnographic records (Charnley 1983; Grønnow et al. 1983: 29ff). It is clear that the large-barbed harpoons should detach from the shaft when the animal was harpooned (Andersen 1972: 74), thus explaining why so many harpoons have been found near inland lakes (Andersen and Vang Petersen 2009: 8ff). The wide geographical and chronological distribution

of the double-rowed harpoons and the large-barbed harpoons suggests that the proposed hunting strategy was important already from the Late Palaeolithic and onwards into the Early Maglemose Culture. During the following Middle and Late Boreal period, this hunting strategy became impossible to carry out, because many inland lakes became overgrown (figs. 6B and 6C).

Another important stray find from Bornholm was an elk antler adze from the small bog called Torupgaard near Klemensker. The artifact was found in 1928 at the bottom of the calcareous marl, indicating a similar date to the finds from Vallensgård. The adze had a length of 20.5 cm and a width of 13 cm. It had a perforation for the shaft at the proximal end measuring approximately 3.5 in diameter. At the distal end, the adze had a 9.5 cm deep oval shaped groove made for an inset or blade (fig. 5). The adze was ^{14}C dated to 9885 ± 55 BP, AAR-13135 (9460–9249 cal BC), making it the earliest artifact on Bornholm. The distribution of these adzes is concentrated around the Baltic Sea (Indreko 1948: 170). But two adzes belonging to the Butovo Culture and situated in the Upper Volga area were found in Russia at Stanovoye 4, indicating a wide mobility pattern of these hunter-gatherers during the Preboreal period (Zhilin 2007: 97ff; Zhilin and Matiskainen 2003: 699).

The Lundebro assemblage and the organic stray finds can thus be interpreted as belonging to a second pioneering group that colonised Bornholm during a favourable period, a period synchronic with a stable land bridge and the migration of reindeer, elk and beaver.

Flora and fauna during the Boreal

During the following Boreal phase (8300–7000 cal BC), a denser forest emerged and the hazel tree (*Corylus*) became a dominant species, although pine could still survive on sandy ground. The earliest ^{14}C results from burnt hazelnut shells dates them to 8900 BP (8300 cal BC) (Casati and Sørensen 2009: 248ff). The warmer temperature lowered the ground water level and the lakes such as Vallensgård Mose became overgrown and filled with peat during the earliest parts of the Boreal phase. The ^{14}C dates from the harpoons and leisters from Vallensgård Mose support this hypothesis (fig. 5). Other flat-bottomed lakes on Zealand such as Barmose, Lundby, Sværdborg and Holmegård also became overgrown at the same time. The same phenomenon is observed in the larger lakes in northern Poland (Alexandrowicz 1999: 67). The fauna is unchanged from the Late Preboreal into the Boreal

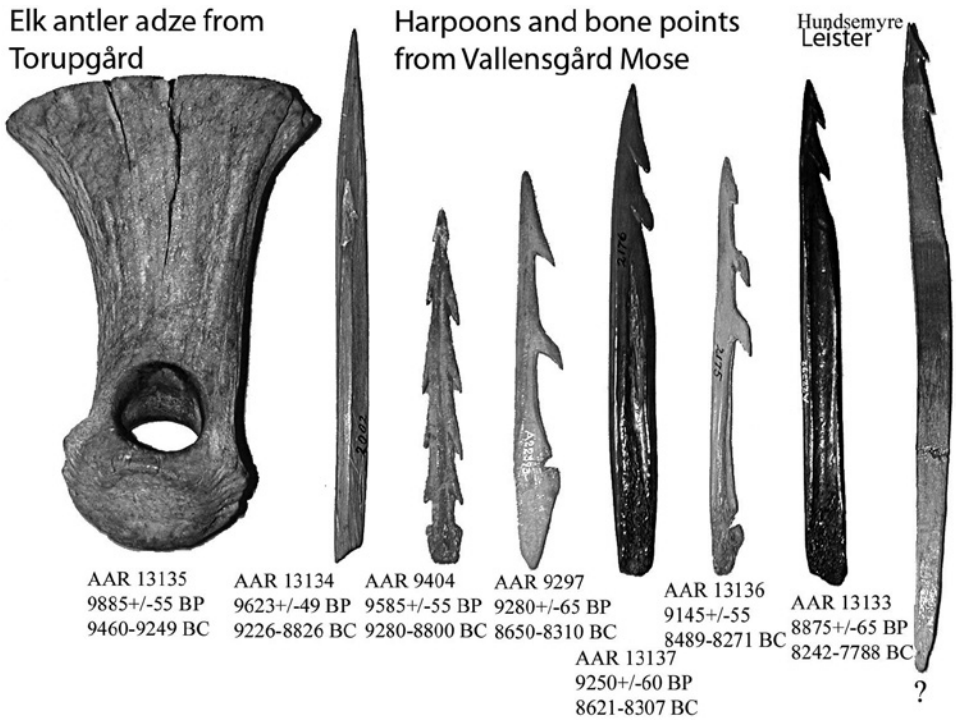


FIGURE 5. ^{14}C dates of the elk antler adze from Torupgård and harpoons and bone points from Vallensgård Mose and Hundsemyre – still undated.

(fig. 4; Aaris-Sørensen 1998: 128). In particular, severely burned bones from wild boar have been observed at Melsted (Becker 1952: 100f), Kobbebro and Ålyst. The only mammal missing so far in the Boreal fauna on Bornholm is the aurochs (*Bos primigenius*). The reindeer became extinct during the Late Preboreal, followed by beaver and elk during the Early Boreal (fig. 5). There could be several reasons for the extinction of the elk, including disease, the emergence of a dense forest and perhaps increased hunting pressure.

Site density during the Maglemose culture on Bornholm

The sparse finds from the early and middle part of the Preboreal indicates that Bornholm was a marginal zone. However, during the Early Boreal, the

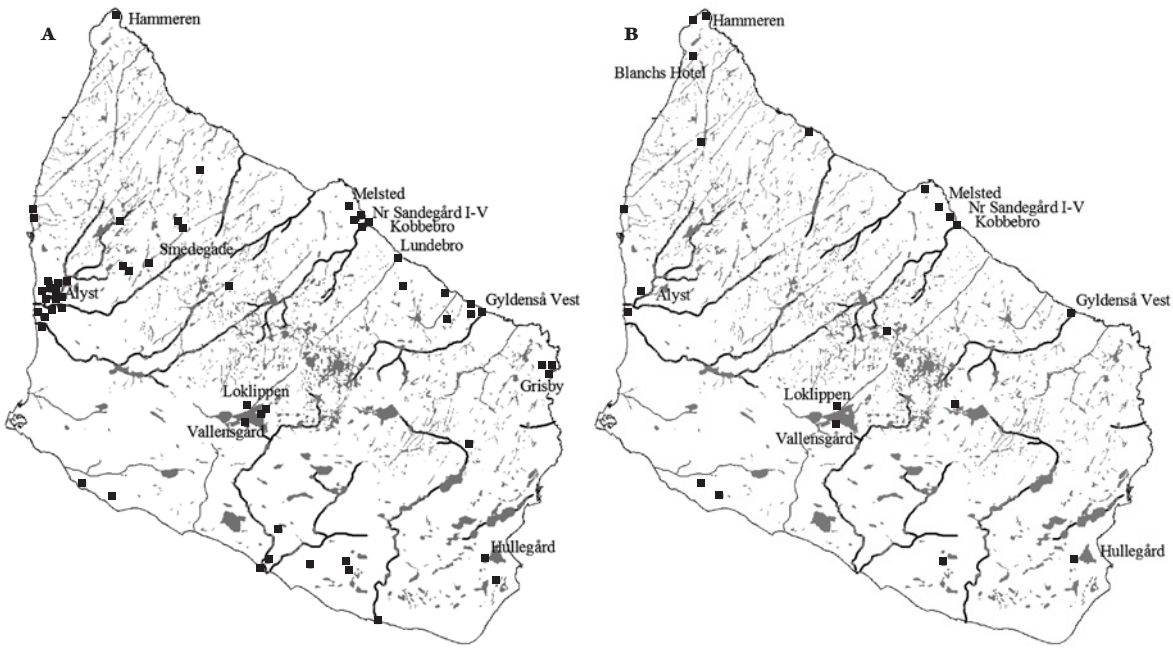
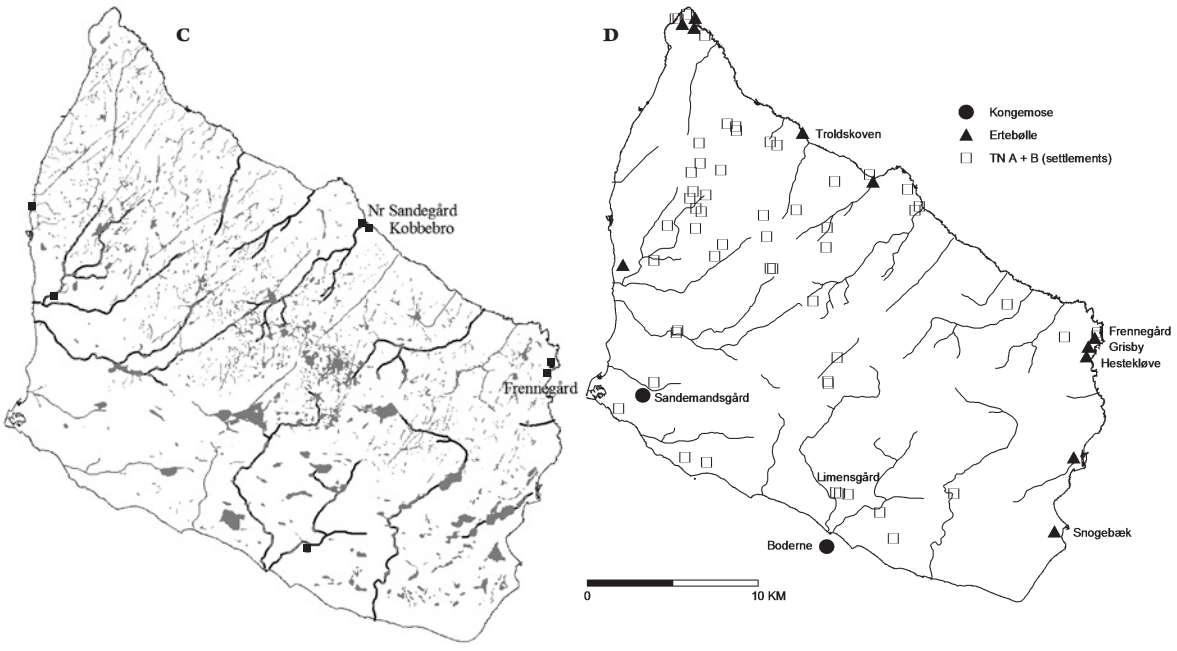


FIGURE 6.
A: Site distribution from the Early Boreal part of the Maglemose Culture.
B: Site distribution from the Middle Boreal part of the Maglemose Culture.

typical Boreal fauna migrates into Bornholm together with the hunter-gatherers, resulting in a high number of Maglemosian sites. These hunter-gatherers exploited the local raw materials, thus revealing a more detailed knowledge of the resources and more permanent habitation within this region. The settlement density during the Boreal on Bornholm can therefore shed some new light on the colonisation process.

Today, more than 125 Maglemosian settlements are known, all associated with the Boreal, a quadrupling of the number published by Becker in 1952 (1952: 152). But most of them are a result of surface collections (figs. 6A, 6B, 6C). The specific location of the different types of settlements on Bornholm gives us a unique opportunity to study the topographical characteristics in our examination. Becker had already demonstrated that the



C: Site distribution from the Late Boreal part of the Maglemose Culture.
D: Site distribution in the Atlantic period during the Kongemose (dot), Ertebølle (triangle) and Early Funnel Beaker (square) Cultures.

Maglemose sites were often found on Late Glacial shorelines, on deposits close to the mouths of larger streams, or on sandy ground alongside these streams (Becker 1952: 152ff). Recent investigations initiated by Nielsen (2001: 89ff) have demonstrated that many settlements are linked to springs or are located on elevated ground with a broad outlook. We have also initiated a survey focusing on sites from inland areas, situated unusually far from any water resources. However, by virtually raising the ground water level on modern maps using GIS, it was possible to recreate the size of the former inland lakes and thereby reconstruct the former landscape and lakes (Casati and Sørensen 2006: 9ff, 2009: 248ff). The majority of the Maglemose sites were then located exactly on the edge of these former lakes (figs. 6A and 6B).

The settlement pattern during the Maglemose culture

The interpretation of the settlement pattern from Bornholm is based on typological studies of the microliths recovered, combined with both technological and ^{14}C analyses of various sites, making it possible to detect long-term changes (Casati and Sørensen 2006: 18ff). The settlement patterns include both coastal, inland and transit camps during the Early to Middle Boreal, suggesting that the habitants lived on the peninsula for a longer period (figs. 6A and 6B). However, it is difficult to determine the seasonality because of poor preservation of the organic materials (Nielsen 2001: 87). The sites are located in areas where it was possible to exploit many resources connected to fishing, hunting and gathering. The majority of excavated sites show a higher density of occupation especially within the Early and Middle Boreal, indicating a repeated settlement pattern closely connected to the larger creeks.

During the Late Boreal there appears to have been a rejection of the interior of the peninsula as a habitation zone (fig. 6C). Instead, sites are clearly concentrated near the coastal zones. Furthermore, the smaller size and limited variability in the tool assemblages, and at some flint concentrations such as Nørre Sandegård II and Ålyst, indicate a shorter duration and habitation within this region (Becker 1990; Casati and Sørensen 2006: 21ff). Why, then, do we see a marked reduction in the population density during the Late Boreal and Early Atlantic?

One of the reasons may be that all the larger inland lakes on Bornholm, including the Vallensgård Mose, became overgrown during the Middle and Late Boreal, resulting in a lost resource and leading to an abandonment of the inland zone. A similar phenomenon is observed in other flat-bottomed lakes on Zealand, where Late Boreal and especially Early Atlantic sites are rare. Another reason could be that the peninsula was flooded during the Late Boreal, creating smaller islands at the banks of Rønne, Adler Ground, Oder bank and Słupsk Shoal (fig. 3C). ^{14}C dates from Adler Ground prove that it was still an island during the Late Boreal and Early Atlantic. The earliest marine ^{14}C date demonstrates that the island was flooded sometime during the Middle Atlantic (Nielsen et al. 2004: 87ff).

The Atlantic flora and fauna

When the land bridge gradually disappeared, something caused by the Littorina transgressions, this did not have any immediate effect on the larger mammals such as red deer, roe deer and wild boar (Aaris-Sørensen 1998: 128). This is confirmed by the faunal remains found at the Late Ertebølle site Grisby, where charcoal from the find-bearing layers has been dated from 5450 ± 90 BP, K-4484 (4456–4051 cal BC) to 4750 ± 70 BP, K-5529 (3651–3371 cal BC) (fig. 4; Vang Petersen 2001: 168). Vang Petersen concludes that the deer population especially was probably much reduced after Bornholm became an island. Arguably, the zoological material presented by Aaris-Sørensen and Vensild (1996: 89ff) indicates a continuous population of red and roe deer on Bornholm, as documented by several Subboreal finds. Only the wild boar seems to have maintained a large population during the Atlantic period, having been found at several zoological locations and at Maglemose (Melsted, Kobbebro and Ålyst) and Late Ertebølle sites (Frennemark and Grisby). Surprisingly, the larger animals in the faunal assemblage thus appear to have survived the isolation of Bornholm, despite the small size of the island (587 km^2). The limited amount of resources could have had an effect on the hunter-gatherer population, as discussed in the following.

The settlement pattern during the Late Boreal and Early Atlantic

During the Late Boreal and Early Atlantic (7000–6000 cal BC), it became impossible to walk to Bornholm, although it is uncertain how low or high the water level was in the Ancylus Lake (8500–7000 cal BC) during these stages. The water level in the Ancylus Lake was probably regulated by the amount of rainfall together with the gradual melting of the North American ice cores. In general, the Atlantic phase has been described as a warm and wet period, but if rainfall was limited during the summer months it could have serious consequences for the trout population, resulting in a smaller population and thus a smaller resource. This could be one of the reasons why we have identified few sites near the streams during the Late Boreal (fig. 6C). The fact that Bornholm became an island does not seem to have resulted in the extinction of the larger mammals (fig. 4). Red and roe deer and the wild

boar continued to be part of the prehistoric fauna on Bornholm, indicating that there were economic reasons for visiting the island. Could the lack of sites be explained by a collapse of the social system within the eastern parts of the Maglemose Culture?

According to Nico Arts (1989: 291), the collapses of social systems from the Late Palaeolithic or Mesolithic are evidenced by:

- A marked reduction in population density
- A decrease in the volume of exchange
- An increase in the proportion of smaller settlements

Our research has already documented a marked reduction in population density and an increase in the number of smaller settlements, resulting in a decrease in the size of individual residence groups and a fragmentation of the social organisation. It is more difficult to identify a decrease in the volume of exchange. The Late Boreal settlements on Bornholm do not contain the same amount of Senonian flint as sites in the Early Boreal phase. Arguably, we need to investigate more sites in order to verify or reject this hypothesis, although it is apparent that there is a continuous decrease in the number of sites from the beginning of the Middle Boreal. Most collapses are caused by persistent stressors, which in the case of Bornholm could be a combination of natural disaster and reduced resources, followed by an emigration away from the region. The natural disaster is documented by the continuous rising of the sea level caused by a rapid climate change, which gradually changed the mobility pattern of the hunter-gatherers. Bornholm was located in the central part of the Maglemose Culture and could have acted as a region of communication between Polish Pomerania and the eastern part of Scania. This could be one of the reasons why Bornholm was visited so many times during the Early and Middle Boreal. During the following phases, the overgrown lakes and warmer summer months, together with an increased hunting pressure on larger mammals when Bornholm became an island, could have reduced the faunal resources. These changes could have resulted in a changed mobility pattern, making Bornholm a marginal area during the Late Boreal and Early Atlantic, as shown by the lower settlement density (figs. 6C and 6D).

Was Bornholm totally abandoned during the Kongemose and Early Ertebølle culture?

Bornholm continued to be a marginal zone, as illustrated by the lack of finds from the Kongemose Culture (6500–5500 cal BC). The exception being a recent find from Sandemarksgård (fig. 6D), which, based on typological grounds, has been dated to the Blak phase (6500–6000 cal BC) (Sørensen 1996). Currently, we have not found a single site from the later phases of the Kongemose and Early Ertebølle Culture (6000–5000 cal BC). A limited occupation during the Early and Middle Atlantic (7000–6000 cal BC) has also been documented on Gotland in St. Förvar (Lindqvist and Possnert 1999: 66ff). However, some submerged sites have been found at Boderne and Sose Odde, proving that the area was not totally abandoned during the early and middle part of the Atlantic (fig. 6D; Nielsen 1986a; Casati and Sørensen 2006: 40). Several submerged sites from the Kongemose and Ertebølle Cultures documented at Lübeck, Wismar Bay and Rügen (Lübke 2004: 85, 2009: 556ff) also add weight to this theory. The use of this submerged landscape and its impact on the settlement pattern is uncertain, but it demonstrates that Bornholm was never out of sight or out of mind for the hunter-gatherers of the Kongemose and Early Ertebølle Cultures. During the following Late Ertebølle Culture (4500–4000 cal BC), many coastal sites were observed on Bornholm. The cylinder-shaped base of the pottery is a typical feature within the sites in Scania and Bornholm, indicating a well-established network across the Baltic Sea during the Late Ertebølle Culture (figs. 1 and 6D). Bornholm was once again an important region located right in the center of the Baltic network.

Concluding remarks

The investigation of the Late Palaeolithic and Mesolithic sites has given us a detailed knowledge of the colonisation process and settlement pattern on Bornholm. The region was settled for the first time during the Bromme Culture, traditionally connected to the Allerød and which was a warm period. In the following Dryas III there is a lack of finds connected to the Ahrensburgian Culture on Bornholm, despite the fact that there were many reindeer in the region. During the following Preboreal, visits to the

area are more frequent, but Bornholm was still a marginal area, only occasionally visited by pioneering hunter-gatherers. This stage was followed by an expansion and consolidation phase during the Early Boreal, caused by improved environmental conditions, shown by a high concentration of sites where local raw materials were exploited and a more residential habitation can be identified. The repeated exploitation of the landscape created some "hotspots" containing a complex of several settlements during the Maglemose Culture.

During the following Middle and Late Boreal, the region became gradually marginalised when Bornholm became an island and lost some of its environmental resources. Additionally, the flooded landscape could have created a collapse of the social system during the Late Boreal. The distances between the mainland and Bornholm flooded landscape created gradually reduced the island to a marginal zone, only occasionally visited by hunter-gatherer groups. It is not until the Late Ertebølle (4500–4000 cal. BC), that we have been able to observe an actual recolonisation of the island.

We have investigated how climate and geographical changes challenged the Stone Age hunter-gatherers on Bornholm. The region is thus an example of how a global climate change during the Early Holocene can create a totally different landscape, which on a smaller regional scale had some major consequences for the hunter-gatherers living in this flooded world. The hunter-gatherers most important faculties were the ability to exploit and maintain cultural as well as social contacts with other Late Palaeolithic and Mesolithic societies in the Baltic region. But the changed landscape, isolating Bornholm as an island, also changed the way hunter-gatherers interacted and communicated. Some regions like Doggerland had to be permanently abandoned, while other regions like Bornholm became marginalised, thus showing the hard priorities the hunter-gatherers had to make, as the abandoned landscape had a history within these people's minds.

Bibliography

Aaris-Sørensen, K. 1998. *Danmarks forhistoriske Dyreverden*. 3rd ed. Gyldendal. Copenhagen.

Aaris-Sørensen, K., and H. Vensild. 1996. "Kronhjortene på Bornholm og især i Aaker sogn." *Bornholmske Samlinger*. III. Række, bind 10, 89–96. Rønne.

Aaris-Sørensen, K., R. Mühldorff and E. Brinch Petersen. 2007. "The Scandinavian reindeer (*Rangifer tarandus L.*) after the last glacial maximum: Time, seasonality and human exploitation." *Journal of Archaeological Science* 34: 914–923.

Alexandrowicz, W. 1999. "Evolution of the Malacological assemblages in North Poland during the Late Glacial and Early Holocene." In M. Kobusiewicz and J. Kozlowski (eds.), *Post-Pleniglacial Re-Colonisation of the Great European Lowland. Folia Quaternaria* vol. 70, 39–69. Krakow.

Andersen, S. H. 1972. "Ertebøllekulturens harpuner." *Kuml* 1971, 73–125. Aarhus.

Andersen, S. H. 1976. "Nye harpunfund." *Kuml* 1975: 11–28. Aarhus.

Andersen, S. H., and P. Vang Petersen. 2009. "Maglemosekulturens stortandede harpuner." *Aarbøger for Nordisk Oldkyndighed og Historie* 2005, 7–41. Copenhagen.

Arts, N. 1989. "Archaeology, Environment and the Social Evolution of Later Band Societies in a Lowland Area." In C. Bonsall (ed.), *The Mesolithic in Europe. Papers presented at the third international symposium in Edinburgh* 1985, 291–312. Edinburgh University Press. Edinburgh.

Baales, M., F. Bittmann and B. Kromer. 1999. "Verkohlte Bäume im Traß der Laacher See-Tephra bei Kruft (Neuwieder Becken). Ein Beitrag zur Datierung des Laacher See-Ereignisses und zur Vegetation der Allerød-Zeit am Mittelrhein." *Archäologisches Korrespondenzblatt* 28: 191–204.

Baales, M., O. Jöris, M. Street, F. Bittmann, B. Weininger and J. Wiethold. 2002. "Impact of the Late Glacial Eruption of the Laacher See Volcano, Central Rheineland, Germany." *Quaternary Research* 58: 273–288.

Becker, C. J. 1952. "Maglemosekultur på Bornholm." *Aarbøger for nordisk Oldkyndighed og Historie*: 96–177. Copenhagen.

Becker, C. J. 1990. *Nørre Sandegård. Arkæologiske undersøgelser på Bornholm 1948–1952*. Historisk-filosofiske Skrifter 13. Copenhagen.

Bennike, O. and J. B. Jensen. 1998. "Late- and postglacial shore level changes

in the southwestern Baltic Sea." *Bulletin of the Geological Society of Denmark* 45: 27–38.

Björck, S. 1995. "A review of the history of the Baltic Sea, 13.0-8.0 ka BP." *Quaternary International* 27: 19–40.

Brinch Petersen, E. 2009. "The Human settlement of Southern Scandinavia 12500–8700 CAL BC." In M. Street, N. Barton and T. Terberger (eds.), *Humans, environment and chronology of the glacial of the North European Plain. Proceedings of Workshop 14. Commission XXXII, The Final Palaeolithic of the Great European Plain of the 15th U.I.S.P.P. Congress, Lisbon, September 2006*, 89–129. Römisch-Germanisches Zentralmuseum, band 6. Mainz.

Casati, C., and L. Sørensen. 2006. "Bornholm i ældre stenalder. Status over kulturel udvikling og kontakter." *Kuml* 2006: 9–58. Aarhus.

Casati, C. and L. Sørensen. 2009. "The settlement patterns of the Maglemose Culture on Bornholm, Denmark." In S. B. McCartan, R. Schulting, G. Warren and P. Woodman (eds.), *Mesolithic Horizons. Volume I,* 248–254. Oxbow Books. Oxford.

Casati, C., L. Sørensen and M. Vennersdorf. 2004. "Current research of the Early Mesolithic on Bornholm, Denmark." In T. Terberger and B. V. Eriksen (eds.), *Hunters in a Changing World*, 113–132. Verlag Marie Leidorf. Rahden, Westfahlen.

Charnley, S. 1983. *Moose hunting in two central Kuskokwim communities: Chuathbaluk and Sleetmute.* Alaska Department of Fish and Game, Technical Paper Nr. 76.

Coles, B. J. 1998. "Doggerland: A speculative survey." *Proceedings of the Prehistoric Society* 64: 45–81.

Fredén, C. 1988. *Marine life and Deglaciation Chronology of the Vänern Basin, Southwestern Sweden*. Sveriges Geologiska Undersökning 71. Uppsala.

Grønnow, B., M. Meldgaard and J. B. Nielsen. 1983. *Aasivissuit – The Great Summer Camp. Archaeological, ethnographical and zoo-archaeological studies of a caribou-hunting site in West Greenland.* Meddelelser om Grønland: Man and Society 5.

Heidelk-Schacht, S. 1984. "Knochen- und Geweigeräte des Spätpaläolithikums und Mesolithikums aus Mecklenburg." *Bodendenkmalpflege in Mecklenburg, Jahrbuch 1983*, 7–82. Berlin.

Indreko, R. 1948. *Die mittlere Steinzeit in Estland*. Kungl. Vitterhets Hist. Och Antikvitets Akad. Handlingar 66. Stockholm.

Iversen, J. 1954. "The late-glacial flora of Denmark and its relation to climate and soil." *Danmarks Geologiske Undersøgelser.* Række 2. Nr. 80, 87–119. Copenhagen.

Jensen, J. B., O. Bennike, A. Witkowski, W. Lemke and A. Kuijpers. 1999. "Early Holocene history of the southwestern Baltic Sea: The Ancylus Lake stage." *Boreas* 28: 437–453. Oslo.

Jensen, J. B., A. Kuipers, O. Bennike and W. Lemke. 2002. BALKAT. Østersøen uden grænser. *Nyt fra GEUS* 4: December 2002, 2–19. Copenhagen.

Karlsson, L., and K. Karlström. 1994. "The Baltic salmon (*Salmo salar L.*): Its history, present situation and future." *Dana* 10: 61–85.

Larsson, L., R. Liljegren, O. Magnell and J. Ekström. 2002. "Archaeo-faunal aspects of bog finds from Hässleberga, southern Scania, Sweden." In B. V. Eriksen and B. Bratlund (eds.), *Recent Studies in the Final Palaeolithic of the European Plain. Proceedings of a U.I.S.P.P. Symposium, Stockholm 1999.* Jutland Archaeological Society Publications 39, 61–74. Aarhus.

Lemke, W. 2004. "Die kurze und wechselvolle Entwicklungsgeschichte der Ostsee – Aktuelle meeresgeologische Forschungen zum Verlauf der Litorina-Transgression." *Bodendenkmalpflege in Mecklenburg-Vorpommeren.* Jahrbuch 2004, Band 52, 43–54.

Lindqvist, C. and G. Possnert. 1999. "The First Seal Hunter Families on Gotland. On the Mesolithic Occupation in the Stora Förvar Cave." *Current Swedish Archaeology* 7: 65–88.

Lübke, H. 2009. "Hunters and fishers in a changing world. Investigations on submerged Stone Age sites off the Baltic coast of Mecklenburg-Vorpommern, Germany." In S. B. McCartan, R. Schulting, G. Warren and P. Woodman (eds.), *Mesolithic Horizons, Vol. 2*, 556–563. Oxbow books. Oxford.

Lübke, H. 2004. "Spät- und endmesolithische Küstensiedlungsplätze in der Wismarbucht. Neue Grabungsergebnisse zur Chronologie und Siedlungsweise." *Bodendenkmalpflege in Mecklenburg-Vorpommeren, Jahrbuch 2004.* 83–110. Lübsdorf.

Nielsen, F. O. 1986a. *Registrering og vurdering af fortidsmindeinteresser på havbunden omkring Bornholm*. Unpublished report to Fredningsstyrelsen 21.04.1986.

Nielsen, F. O. 1986b. *Arkæologiske udgravninger i Danmark* 1986. Det Arkæologiske Nævn, 77. Copenhagen.

Nielsen, F. O. 2001. "Nyt om Maglemosekultur på Bornholm." In O. Lass

Jensen, S. A. Sørensen and K. M. Hansen (eds.), *Danmarks Jægerstenalder – status og perspektiver,* 85–99. Hørsholm.

Nielsen, P. E., J. B. Jensen, M. Binderup, S. Lomholt and A. Kuijpers. 2004. Marine aggregates in the Danish sector of the Baltic Sea: geological setting, exploitation potential and environmental assessment. *Zeitschrift für Angewandte Geologie,* Sonderheft 2, 2004, 7–09.

Noe-Nygaard, N., K. L. Knudsen and M. Houmark-Nielsen. 2006. "Fra Istid til og med Jægerstenalderen." In K. Sand-Jensen (ed.), *Naturen i Danmark,* vol 1., 303–332.

Riede, F. 2008. "The Laacher See-eruption (12,920 BP) and material culture change at the end of the Allerød in Northern Europe." *Journal of Archaeological Science* 35: 591–599.

Sarauw, G. F. L. 1903. En stenalders boplads i Maglemose ved Mullerup, sammenholdt med beslægtede fund. *Aarbøger for Nordisk Oldkyndighed og Historie,* 148–315. Copenhagen.

Schmincke, H.-U., C. Park, and E. Harms. 1999. "Evolution and environmental impacts of the eruption of Laacher See volcano (Germany) 12,900 a BP." *Quaternary International* 61: 61–72.

Street, M. 1986. "Ein Wald der Allerödzeit bei Miesenheim, Stadt Andernach (Neuwieder Becken)." *Archäologisches Korrespondenzblatt* 16: 13–22.

Sørensen, L. 2010. "The Laacher See volcanic eruption. Challenging the idea of cultural disruption." *Acta Archaeologica* 81: 276–287.

Sørensen, S. A. 1996. *Kongemosekulturen i Sydskandinavien*. Egnsmuseet Færgegården.

Terberger, T. 2006. "The Mesolithic Hunter-Fisher-Gatherers on the Northern German Plain." In K. B. Pedersen and K. M. Hansen (eds.), *Across the Western Baltic,* 111–184. Sydsjællands Museum. Vordingborg.

Uścinowicz, S. 2006. *How the Baltic Sea was Changing.* Online report on the Polish Geological Institute webpage: www.pgi.gov.pl

Usinger, H. 1977. "Bölling-Interstadial und Laacher Bimstuff in einem neuen Spätglacial-Profil aus dem Vallensgård Mose/Bornholm. Mit pollengrössenstatistischer Trennung der Birken. " *Danmarks geologiske undersøgelser, årbog 1977,* 5–29. Copenhagen

Vang Petersen, P. 2001. "Grisby – en fangstboplads fra Ertebølletid på Bornholm." In O. Lass Jensen, S. A. Sørensen and K. M. Hansen (eds.), *Danmarks jægerstenalder – status og perspektiver,* 161–174. Hørsholm.

Vang Petersen, P. 2009. "Stortandede harpuner – og jagt på hjortevildt til

vands." *Aarbøger for nordisk Oldkyndighed og Historie*, 43–54. Copenhagen.
Zhilin, M. 2007. "The Early Mesolithic of the Upper Volga: Selected Problems." In M. Masojć., T. Płonka, B. Ginter and S. K. Kozłowski (eds.), *Contributions to the Central European Stone Age*, 89–103. University of Wrocław Institute of Archaeology. Wrocław.
Zhilin, M., and H. Matiskainen. 2003. "Excavations at the Mesolithic sites Stanovoje 4 and Sakhtysh 14, Upper Volga region." In L. Larsson, H. Kindgren, K. Knutsson, D. Loeffler and A. Åkerlund (eds.), *Mesolithic on the Move. Papers presented at the Sixth International Conference on the Mesolithic in Europe, Stockholm 2000*, 694–702. Oxbow books. Oxford.